DOCUMENT RESUME

ED 388 262 IR 017 411

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TITLE Children's Independent Exploration of a Natural Phenomenon by Using a Pictorial Computer-Based Simulation.

PUB DATE 94

NOTE 7p.; In: Educational Multimedia and Hypermedia, 1994. Proceedings of ED-MEDIA 94--World Conference on Educational Multimedia and Hypermedia (Vancouver, British Columbia, Canada, June 25-30, 1994); see IR 017 359.

PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS Case Studies; Children; *Cognitive Development; *Cognitive Processes; *Computer Simulation; *Concept Formation; Educational Technology; Foreign Countries; Grade 1; *Natural Sciences; Primary Education

IDENTIFIERS Finns

ABSTRACT

Using a pictorial computer simulation of a natural phenomenon, children's exploration processes and their construction of conceptual models were examined. The selected natural phenomenon was the variations of sunlight and heat of the sun experienced on the earth in relation to the positions of the earth and sun in space, and the subjects were 7-year-old Finnish first graders. When a child explored the simulation, each press of the mouse was recorded in the computer's memory, in order to note exploration pathways; pathways were then transferred to paper and a description technique was developed for them. Two tables show this technique and an example of a child's exploration pathway using the technique. Children's conceptual models were examined before and after the exploration of the natural phenomenon. Before the use of the simulation, children's conceptual models were at very different levels; during use, conceptual models developed in varying amounts, with knowledge constructions moving in the same general direction. (AEF)

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Children's Independent Exploration of a Natural Phenomenon by Using a Pictorial Computer-Based Simulation

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ED 388 262

Abstract: This paper describes an investigation examining the constructing of a conceptual model of a selected natural phenomenon by children when using a pictorial computer simulation of that phenomenon. The paper concentrates on describing children's exploration process in relation to their conceptual models before and after the use of the simulation. The selected natural phenomenon was the variations of sunlight and heat of the sun as experienced on the earth related to the positions of the earth and the sun in space. Children's conceptual models before the use of the simulation formed a starting point from which the exploration of the phenomenon was activated. Children's exploration seemed to contain, for example, wandering here and there, investigating and seeking for something and experimenting with aim. During the exploration process occured the construction of conceptual models in varying amounts but the construction seemed to follow a correctly directed conceptual model of that phenomenon.

This paper is one part of an investigation whose aim was to investigate to what extent the independent use of a pictorial computer simulation of a selected natural phenomenon could be of help in the organizing of the phenomenon and the forming of an integrated picture of that phenomenon. Attention was paid to the constructing of a conceptual model of the phenomenon by children and children's exploring process during the use of the computer simulation. This paper concentrates on examining children's exploring process and its relation to the constructing of children's conceptual models by using a pictorial computer simulation of that phenomenon. The children taking part were seven-year old Finnish first-graders. They had at school no formal instruction before or during their exploration process of this natural phenomenon. The author has not found any corresponding works.

In this work a conceptual model of a natural phenomenon is seen as a mental construct which is based on activated information stored in the interconnected neural networks of the brain concerning a phenomenon in question. A conceptual model has been formed from the basis of the regularities of a natural phenomenon. It covers the events, objects, properties and relations of a natural phenomenon. A conceptual model makes it possible to think about a phenomenon, to describe it, and to explain and to predict the events of the phenomenon. In a conceptual model, conceptual refers to activated information in the neural networks, and a model of a phenomenon forms when interconnected neural networks concerning a phenomenon are activated.

This paper first describes the pictorial computer simulation of a selected natural phenomenon. After it procedures for the examination of children's exploration process are described and finally children's exploration process and its relation to changes in children's conceptual models before and after the use of the simulation is examined.

Pictorial Computer Simulation

The selected natural phenomenon for the pictorial computer simulation was the variations of sunlight and heat of the sun as experienced on the earth related to the positions of the earth and the sun in space. In the simulation it is possible to explore the variations of sunlight and heat of the sun and their effects on the earth in a natural environment and the origin of these phenomena from the basis of the interconnections and positions of the earth and the sun in space. The simulation concentrates on phenomena which are close to the everyday experiences of children, such as day and night, seasons, changes in the life of plants and birds etc. The simulation program has been implemented in such a way that the knowledge structure and theory of the

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phenomenon are based on events appearing together with the phenomenon in question, and these events are illustrated. In the simulation all events and necessary elements are represented as pictures and familiar symbols. At the earth level the pictorial simulation represents the surrounding world, its phenomena and objects in a very natural and realistic way. In exploring the phenomenon at the space level the interrelations of the earth and the sun are represented with the help of an analogue model. The selected place on the earth from where the phenomenon has been modeled and simulated for a computer is the suburb of Lentävänniemi in Tampere, in Finland. The children who participated in this research live in this area. Therefore the exploration of the phenomenon with the pictorial simulation takes place in an environment familiar to the children.

The computer program begins so that on the screen appears the earth revolving on its elliptical orbit around the sun. A child can see the whole revolution of the earth around the sun and can continue at any time to the next phase where the name and age of a child is asked. Next a map of Finland appears on the screen and by pressing the position of the city of Tampere on the map a view from Lentävänniemi toward the south is seen on the screen.

The exploration of the phenomenon starts in Lentävänniemi on the 1st January at midnight. On a big screen is seen at that moment a dark, snowy, winter landscape in a direction of the south. The exploring can be continued by using icon pictures under the picture of the landscape, for example, a clock, a pictorial calendar, a picture map with different points of the compass and a space shuttle. The exploring of the phenomenon can be continued in many ways hour by hour, day by day, month by month, at different points of the compass and so on. At any moment it is possible to take a space shuttle and to look at the interrelations and positions of the earth and the sun at the space level. At the space level it is also possible to explore the interrelations and positions of the earth and the sun by using icon pictures which show the time in the same way as at the earth level. At every moment it is possible to choose how to continue exploring. Exploring can proceed at every moment using the existing alternatives.

When exploring at the space level the earth, rotating around its axis and revolving around the sun on its elliptic orbit, appears on the screen. The plane of the earth's orbit is shown as viewed from directly above this plane. When exploring the phenomenon at the earth level the following may appear on the screen: the changes of darkness and lightness daily with an accuracy of one hour, the sun's positions in the sky every hour, the place and time for the sunrise and the sunset every day round a year, typical plants, birds and animals according to seasons and so on. With the help of the icon pictures, binoculars, magnifying glass and microscope it is possible to explore flowers, trees, leaves, insects, birds, spores, animals and so on in more detail. On the screen a selected object is seen as bigger. At the space level with the help of a telescope it is possible to look at the earth at a larger size so that, for example, Finland is seen more clearly. From this picture of the earth it is possible to continue further and to see the map of Finland, and finally an air photo of Tampere. In the simulation it is also possible to explore the mutual size of the earth and the sun and to get an image of the distance between them. Also the position of the earth in the whole solar system can be seen on the screen. The pictorial computer simulation is constructed so that it is very easy to use and it does not presuppose an ability to read or write. A pictorial computer simulation (Kangassalo 1991) is described in details in the article by Kangassalo (1992).

Examination of Children's Exploration Process and Description Techniques

When a child explored a phenomenon by using simulation each press of the mouse was recorded in the computer's memory. Presses were recorded so that it was possible afterwards to recall, from the computer's memory the children's exploration pathways and to see each child's exploration pathway on the screen. On the screen a child's exploration pathway can be seen press by press as pictures like it occured in the exploration situation. Children's exploration pathways were recorded from the computer's memory on to paper and a description technique was developed for them. The description technique makes it possible to follow children's exploration process as it happened in the original situation. In the description technique it can be seen on which levels of the phenomenon a child's exploration took place. Table 1 shows this technique. In the technique the following levels can be separated: earth/space, the point of the compass on the earth, month (including season and month), day (including number of a day, time, awake/sleep), research mediums (at space level also the scale and the solar system) and finally details. In Table 2 an example is shown about a child's first exploration pathway by using the described technique.

Table 1.
The description technique for children's exploration pathway.

1 st January 00 o'clock on the earth the point of the compass is south
point of the compass
season
month
number of a day
time
awake/sleep
research medium
detail
space shuttle to space:earth-sun
season
month
number of a day
time
awake/sleep
research medium
map of Finland
air photo of Tampere
scale
solar-system
scale
back to earth-sun
space shuttle to earth

Table 2.
The first exploration pathway of a child.

1 st January 00 o'clock on the earth the point of the compass is south
awake
east
season
2 nd
binocular
sparrow
space shuttle to space: earth - sun
telescope
scale
solar system
scale
back to earth - sun
space shuttle to earth
season
magnifying glass
raspberry flower
measuring worm
ladybird
dragonfly
space shuttle to space: earth - sun
scale
back to earth - sun
12
awake
telescope
map of Finland
air photo of Tampere
space shuttle to earth

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The second description technique has been developed with the purpose of summarising and clarifying a child's exploration subjects at different exploration times. An example of this technique is seen in Table 3. In this table has been described all icons by which it is possible to explore the phenomenon both at the earth level and at the space level. In this table can be seen what a child explores, how many times and how extensive an exploration is. By examining all a child's exploration times as separate tables it is possible also to see in which order a child explores the things of the phenomenon. Both description techniques support and are complementary to each other. The descriptions of the exploration pathways shows a child's exploration processes step by step and from tables they can be seen in summary. By means of the descriptions of exploration pathways and tables can be followed the construction process of children's conceptual models.

Table 3.
The first exploration pathway of a child as a table.

Child: 1
Date: 20.11.1991
Number of frames: 28
Time: 11 min

	On the earth				In space
	south	east	west	north	
season		2			
month					
day		1			
hour					1
awake/sleep	1				1
binoculars		1			
details		1			
magnifying		1			
details		4			
microscope					
details					
telescope					2
map					1
photo					1
scale					3
solar system					1
point of	1	shift in space			2
space shuttle	4				

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Children's Exploration Process and Its Relation to Children's Conceptual Models

Before and after the exploration of the natural phenomenon children's conceptual models have been elicitated by using procedures for this aim (see Kangassalo 1993a). Before the use of the simulation children's conceptual models were at very different levels. Some children's conceptual models of the phenomenon were quite undeveloped, and some others' very developed. Only some children's conceptual models contained a clear misconception. During the use of the simulation in children's conceptual models changes occured. The most significant change was that the interconnections of different phenomena and entities began to be constructed and the construction seemed to follow the currently accepted scientific knowledge.

In the construction of the interconnections of phenomena and entities the following phases could be seen: the existence of interconnections had been discovered, the organization of interconnections took shape (order, continuity and regularities), the amount of interconnections increased, the reorganization of interconnections took shape: interconnections ceased to exist or/and interconnections replaced by other interconnections.

In the natural phenomenon in question the main direction of constructing by children tends to be as follows:

1. The earth begins to revolve around the sun.
2. Seasons are organized in the everyday world and are connected to the positions of the earth and the sun in space.
3. The alternation of darkness and lightness on the earth is seen to have resulted from the turning or revolving of the earth in the earth's orbit.
4. The alternation of darkness and lightness and the succession of seasons has been seen to have resulted from the rotation of the earth around its axis once every 24 hours while the earth is revolving around the sun, a circuit around the sun taking place once a year.
5. In conceptual models which before the use of the simulation, the sun was revolving around the earth in two cases out of three the sun did not revolve anymore around the earth after the use of the simulation.

The children's exploration process is examined next from the basis of their conceptual models before the use of the simulation. Children were divided into four groups according to what kind of conceptual models they had before the use of the simulation. Children's conceptual models before the use of the simulation formed a starting point from which the exploration of the phenomenon was activated. Children's conceptual models and changes with in them can be read more precisely in Kangassalo's article 1993b.

The first group consisted of children (3/11) whose conceptual models before the use of the simulation were quite vague and undeveloped. After using the simulation a significant change in their models was that the earth began to revolve around the sun. The exploration of the phenomenon by two of these three children took place quite randomly at the earth level. They looked into the space level now and again but returned almost by the same way back to the earth level. One of these three children explored the phenomenon at the earth level more extensively than the other two and looked into the space level quite often. In this child's conceptual model after the use of the simulation the order, continuity and regularity of seasons in the everyday world had been discovered. The child used the simulation many times and her operating time was altogether one of the longest in the whole group of eleven children.

A little more developed were the conceptual models of four children (4/11). The order, continuity and regularity of seasons on the earth were quite well organized except one. Some light interrelations of phenomena on the earth and in space had been noticed. In these children's models, after the exploration process, the earth is revolving around the sun and the succession of seasons on the earth was perceived to be connected with the positions of the earth and the sun in space. The association of the alternation of lightness and darkness and the succession of seasons in the positions of the earth and the sun in space model proved to be problematic.

In this second group one child's conceptual model before the use of the simulation was somewhat uncertain about the succession of seasons on the earth but in his model the earth goes round. This child's exploration of the phenomenon was directed to phenomena on the earth. He explored very carefully and many times months at different points of the compass and systematically looked for details month by month. He looked into the space level very often almost in every season and used the telescope frequently to see the earth enlarged. The exploration of the phenomenon at the space level by the use of time characters took place only some times. After the exploration process in his conceptual model the succession of seasons were well organized both at the earth level and at the space level. The association of the alternation of lightness and darkness and the succession of seasons at the space level did not take place.

Two children of this second group explored the phenomenon mainly at the earth level looking briefly into the space level. In their models the earth was revolving around the sun and seasons on the earth were perceived to be connected with the positions of the earth and the sun in space. Connections in their models were still quite weak.

The fourth child of this second group explored the phenomenon the longest time (112 minutes) out of the whole group of eleven children. He started to explore the phenomenon on the earth. At first he looked for details according to seasons and months. Gradually he used the icons of the clock and days and after that he moved to explore at the space level. At the space level he explored the movement of the earth by using the clock, days and months. Sometimes now and then he looked into the earth. The child's exploration was systematic and took place with aim. Some degree of experimenting also occured especially at the latter part of the exploration process. After the use of the simulation in his model the earth is revolving around the sun and the succession of seasons on the earth was perceived to be connected with the positions of the earth and the sun in space. The association of day and night and succession of seasons at the space level did not take place. In his model these things were separate, so that daylight on the earth, in Tampere, is when the earth is on the other side of the sun and dark when it is on the opposite side of the sun.

The third group consisted of one child whose conceptual model of the phenomenon was very well developed before the use of the simulation. The only undeveloped thing in his conceptual model was the reconciliation of the alternation of lightness and darkness and the succession of seasons with the positions of the earth and the sun at the space level. During the exploration process the reconciliation was made. This child explored the phenomenon quite thoroughly both on the earth and in space. When using time icons, season, month, hour and day, the exploration took place side by side on the earth and in space.

The fourth group consisted of three children (3/11) whose conceptual models contained a clear misconception. In their models the sun was revolving around the earth. After the use of the simulation, two of the children's conceptual models became disintegrated. The sun's revolution around the earth was absent and interrelations of phenomena on the earth and space became weaker. One child's model remained almost unchanged. From these children's exploration there can not be seen any uniformity. One child whose model after the exploration process was disintegrated explored the phenomenon noticeably at both the earth level and the space level by using the time icons. The other child's exploration was quite random wandering and amusing. The child whose model remained almost unchanged used mainly the season and month icons on the earth level. Now and then he amused with the space shuttle and looked into the level of the solar system.

Summary about results

Children's conceptual models before the use of the simulation formed a starting point from which the exploration of the phenomenon by children was activated. Children's exploration processes seemed to contain wanderings here and there, investigating and seeking for something and experimenting with aim. Sometimes children amused themselves with the space shuttle and some children made tales about animals. The more developed and integrated conceptual model, the more children's exploration contained investigating and experimenting with aim. Children's conceptual model of the phenomenon develops and constructs during the exploration process in varying amounts but the main direction of constructing tended to be the same and seemed to follow the currently accepted scientific knowledge.

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Acknowledgements

I express my great thanks the Academy of Finland and the University of Tampere for the financing of my research, and the Department of Education, University of Tampere, for the excellent working circumstances.